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Pathogenic bacteria in man

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Introduction

The botanical group of Schizomyces or fission fungi is composed of bacteria which are the creators of nearly all human and animal diseases as well as the causative agents at work during putrefaction and decay. These two activities make bacteria more important economically than the protozoa.

As there is still so much sickness not only of an acute but of a chronic nature which retards the social and economic efficiency of the population as a whole, a discussion of bacteria and their relationships to diseases—a subject in which I have for some time been interested—does not seem untimely.

True, the death rates and the total number of cases each year of many of the common and the more serious diseases are being checked. A constant and steady decrease can be traced in tuberculosis, pneumonia, diphtheria, and the fight against smallpox seems to be won. Still, suffering continues due to the wide distribution of bacteria throughout the world. In the soil even at great depths in the air especially at low altitudes, and in water whether it is in a liquid form or as ice, bacteria occur in remarkably large numbers. Working side by side with the factors of distribution is the congestion of the large cities and the ignorance of the masses; thus making very
difficult the control of bacterial invasion.

A discussion of the morphology of the bacteria with their methods of reproduction, locomotion, and a classification will be followed by a short treatment of the resistance of the host and its susceptibility to invasion. Science has helped the medical profession to perfect the prophylactic and curative measures which are important for combating these destructive microorganisms. As the main body of this treatise, the important pathogenic or disease-producing bacteria will be described in detail. The clinical pictures of growth, types of media, cultivation, sterilization, and staining with its detailed microscopic work have been omitted as they are studied in a laboratory course.

There were two main factors which prepared the way for the work of our greatest scientists. First there was the discovery of the microscope and its subsequent improvement. Then the fallacy of the long believed and widely accepted theory of spontaneous generation was established.

Louis Pasteur was a nineteenth century scientist who took an active part in the prevention and relief of human suffering. Henry Fairfield Osborne has called him "the greatest benefactor of mankind since the time of Jesus Christ". (1)

After long and careful studying, clear thinking, and well per-

(1) Osborne, Impressions of Great Naturalists p. 117
formed experiments, he came to the conclusion that living bacteria were the cause of the souring of milk and that they also had an active part in fermentation processes. This led him to attempt to discover the origin of contagious diseases. While working with chicken cholera, he discovered that cultures which had been kept for sometime and had become weakened caused only a slight infection. Then if these fowls were reinoculated with a virulent strain no infection appeared for they had become immune. This gave evidence for a general application, and so he tried the same experiment with the anthrax bacilli. At the time it was causing a large number of deaths among sheep and cattle. The experiment was a success and with patience he was able to convince a doubting audience of learned men. In 1880 Pasteur began his work on rabies. He thought the site of the infection was in the medulla oblongata, the portion of the spinal cord nearest the brain. After discovering the cause and location of the infection there was the problem of preventive treatment. At first working with rabbits and afterwards using dogs bitten by mad dogs he worked out a formula which decreased the number of animal deaths resulting from rabies. What of human treatment? Before the experiments were finished, he was forced to treat a small boy who had been bitten in fourteen different places.
The Rabies Commission backed him and after much anxiety and several sleepless nights the treatment proved successful.

In February of last year one Joseph Meister of Paris came to America for his first visit. He, according to a newspaper article, was this nine year old boy to whom Pasteur had administered the first treatment, and whose life had been saved. The purpose of his visit was to stimulate a new interest in Pasteur. (1)

Sir Joseph Lister, getting an inspiration from Pasteur's germ theory of putrefaction introduced antiseptic methods of operating into the field of surgery. He maintained that he had only made practical applications which were based upon his friend's discovery. He experimented with drugs and produced antiseptics which would effectively kill the germs of decay. With these new solutions he was able to keep the injured tissue free from bacteria. At the time more deaths were being caused by secondary infections than from the operation because the original causes of the disease were overshadowed by the use of septic instruments and other uncleanly conditions.

Robert Koch, a German and first class scientific investigator, was born in 1843. He demonstrated the relationship between microorganisms and infections. From his work

(1) American Journal of Public Health April, 1936 p. 363
with bacteria he proposed four postulates. First one must be able to find the same organism present in all cases of the disease. Then cultivate it in a pure culture outside the body. Third, after inoculation of a susceptible animal the same disease must appear. Last, the organisms should be found in lesions of this animal.

In 1905 Koch was awarded the Nobel prize, and three years later he came to America to participate in the International Tuberculosis Congress which was held at Washington. "Whole empires have flourished and perished without contributing as much to the sum of human knowledge as that one man, Robert Koch." (1)

(1) Robinson, Pathfinders in Medicine p. 746
Morphology of Bacteria

Leeuwenhoek, no doubt, was the first to describe bacteria, but he mistook them for animals because of their motility. Further investigation proved them to be closely related to the algae as well as to the fungi in as much as bacteria lack chlorophyl. There is no difficulty determining the higher plants from higher animals, but there are many plants in the lowest phylum, Thallophyta, which cannot be distinguished from organisms in the first phylum, Protozoa, of the Animal Kingdom. It is the intermediate forms which cause the difficulty in classification because bacteria in the Thallophyta group oftentimes resemble the protozoa. The fact that an organism possesses flagella is not sufficient evidence to call it an animal. Both plants and animals employ this means of locomotion. Generally plants can be separated from animals because of their firm well differentiated cell wall which differs from the protoplasm; its composition having been chemically analyzed as cellulose. In the one-celled animals, besides containing a large number of food vacuoles, the outer portion of the protoplasm is the cell wall. However, according to Holman and Robbins, bacteria differ from typical plants for their cell walls are very similar to the protoplasm. (1) The latter is bounded by a semi-permeable membrane, and plasmolysis can be demonstrated as proof of this condition.

The most widely accepted theory of the origin of bacteria states that they are descendants of the Blue Green Algae. Because of the lack of plastids and the pigment chlorophyl, bacteria except for

(1) Holman and Robbins, Elements of Botany pp. 245-50
The nitrogen bacteria have had to develop a saprophytic or parasitic mode of life rather than carry on holophytic nutrition. The food must necessarily be in solution so as to be absorbed through the cell wall. The cell structure is simple and almost identical with the structure of algae which like bacteria usually are found under more or less moist conditions. Neither the bacteria nor the blue green algae reproduce by means of gametes, a sexual type of propagation. (1)

Bacteria and yeasts may appear superficially to resemble one another because of the fact that each is one celled. However bacteria reproduce by transverse fission and the yeasts by budding. When properly stained the nuclei of the bacteria appear as diffuse particles while in the yeast cell a well differentiated nucleus can be demonstrated.

Each individual bacterium is a single cell averaging about \( \frac{1}{25,000} \)ths of an inch in diameter. Each is strictly self-sufficient; but often they are aggregated in a matrix of gelatinous material to form masses of filaments or colonies.

Morphologically bacteria consist of a cell wall which is a thin layer of denser material bounding the homogeneous protoplasm. The latter theoretically can be divided into cytoplasm and nuclear material, although the distinct parts cannot be separated. The cytoplasm is granular and contains the metachromatic bodies. The nuclear material is scattered through it and has no definite structure. This led to the prevalent belief that bacteria were non-nucleated. Improved cytological

(1) Smith, Overton and Allen, Textbook in General Botany p. 241
technique disproved this theory, showing chromatic granules. These ordinarily stain deeply, but in bacteria the whole body stains due to the distribution of the nuclear material.

Many bacteria, especially bacilli and spirilla, have flagella, the chemical composition of which is not definite. These may be arranged in a large variety of positions. Specific names are applied according to this arrangement. Monotricha designates a flagellum at one pole, Siphonricha when there are several flagella at one end, Amphiwicha designates a flagellum at each pole, and finally peritrichal bacteria have numerous flagella surrounding the body.

The cocci most often occur without flagella. Thus, they would be termed immotile. In 1827 Robert Brown discovered that they exhibit a vibration when suspended in liquid. He showed that the motion was due to the molecules in the liquid striking the bacterial cells. In his honor this motion has been termed Brownian Motion.

Multiplication, demonstrated by actual observation, is by means of binary fission. This is a simple non-sexual reproductive method. The daughter cells are formed from a constriction in the cell wall. The process requires about fifteen minutes time to be completed, and as a result in the course of one day about a trillion bacteria are capable of being generated from a single bacterium. Fortunately environmental conditions check this rapid growth and the number of progeny is greatly limited. The fission is always transverse and never longitudinal; the result is two daughter cells of equal size.
Multiplication takes place when the environment is normal, but when these external conditions become unfavorable for ordinary growth, spores are formed. Their production is not a means of reproduction but an ingenious method by which the species is prevented from being wiped out. Each individual engenders one spore and by so doing gives up its entity. When there is a lack of water the protoplasm shrinks and a thick wall forms around it. This spore remains alive over long periods, resisting extreme temperatures, drying and disinfectants. When the environment has been rendered normal again and favorable for growth, the contents of the cell burst through the spore wall germinating into a new individual. A special type of spore most often found in the bacilli and spirilla is the endospore. This spore is of greater diameter than the previous cell wall, and this swelling is known as a clostridium. One very characteristic type of clostridium is found in anaerobic bacteria. Here the swelling occurs at one pole and resembles a drumstick—the name popularly used. Fortunately, spores of the dormant stage of bacteria occur in relatively few of the pathogenic strains.

Bacteria are often times enclosed in gelatinous capsules. These are of two types. A true capsule, which is a secretion mucinous in composition, is produced by the cell. It is often described as pseudomucinous or glycoprotein. This capsule may be seen in preparations which have been stained with a special capsule stain. Certain species are characterized by the presence of this capsule. Such is the case when attempting to distinguish between pneumococci.
and the other spirilla. In some cases the species which produce a capsule do so only in animal tissue. The anthrax bacillus is a good example of a pair of cocci enclosed in this manner. The second type of capsule is the so-called "culture capsule" which is formed on the culture media exclusively and is deposited on the outside of the organism. Both types of capsules are for protective purposes.

Bacteria are divided according to their morphology into three groups. There are the bacilli, the cocci, and the spirilla. The former are rod-shaped, however, many of them are so short as to appear oval. The cocci or circular bacteria are further divided, reference being made to the relationship of each spherical cell to the other. The spirilla are curved with a suggestion of a spiral. The following classification which Belding and Marston have condensed seems to fit the need of this paper.

Classification:

1. Cocccaceae
   a. Micrococci  
   b. Streptococci  
   c. Sarcinae  
   d. Planococci  
   e. Planosarcinae
   spherical cell in a free state
   resemble a cluster of grapes
   bead-like chains
   bale-like packets
   motile cocci with flagella
   motile sarcinae with flagella

2. Bacteriaceae
   elongated and cylindrical or straight cells
   non-motile
b. bacillus motile with peritrichal flagella

c. Pseudomonas motile with polar flagella

3. Spirilla

   a. Spirocoma elongated and cylindrical cell
   b. Microspira spirally twisted about a long axis
   c. Spirillum cells rigid without flagella
   d. Spirochaeta cells rigid rarely two or three polar flagella

   d. Spirochaeta cells sinuously flexible with polar flagella

4. Chlamydotbacteriaceae cells enclosed in a sheath united in branched or unbranched threads

   a. Streptothrix cells joined in simple unbranched threads division in one plane
   b. Gladothrix pseudodichotomous branching division in one plane
   c. Gramothrix cell division in three planes unbranched threads
   d. Phragmidiothrix cell division in three planes branching
   e. Thiothrix unbranched threads in sheath division in one plane sulphur granules

5. Beggionaceae cells united in threads with sheath division in one plane undulating membrane
Physical agencies such as temperature, light, electricity, and osmotic pressure all have a certain amount of effect upon the growth and well being of bacterial cells. The temperature influences the organisms more than the other external conditions. Each individual bacterium flourishes at a different temperature. The temperature at which a bacterium grows best and reproduces most prolifically is the optimum temperature. Those bacteria whose optimum temperature is relatively high are known as thermophils. Those which have a medium temperature range are the mesophils. Some grow best under conditions which are cold, these are the psychrophils. The majority of bacteria like an environment which is the same as the body temperature, that is 37°C. Many prefer 22°C or about room temperature. This is true of bacteria which normally live in the water and soil. Bacteria will, however, carry on the necessary life processes at temperatures which are either very much higher or lower than the optimum temperature. The lowest degree at which they can possible live is the minimum temperature and, as may be expected, the maximum is the highest possible temperature the cells can endure.

Light effects growth as well as the temperature, but not to such a large extent. Many bacteria prefer darkness and sunlight destroys nearly all types of bacteria especially the tubercle bacillus. Bacteria of the water flora are killed when they are exposed to ultra-violet light. In contrast electricity or the passing of an electric current through the cells shows little influence on the

(1) Belding and Marston, A Manual of Medical Bacteriology p. 7
Osmotic pressure produces two significant results. The first, plasmolysis, is the shrinking of the protoplasm due to the loss of water by the cell. Then by increased pressure a large quantity of water is forced into the cell causing it to swell until it finally bursts. This latter is known as plasmoptysis.

Oxygen is necessary in most cases for the growth of organisms. They are known as aerobes. A few prefer an environment where the oxygen supply has been shut off. The anaerobes belong in this group. Both the aerobes and the anaerobes can be further differentiated, as members of each group require varying amounts of oxygen. Those which are able to adapt themselves to the presence or absence of oxygen are called facultative. Thus a facultative anaerobe is one which prefers conditions where there is no oxygen but will not necessarily be killed in its presence. On the other hand there are members of both groups which must have a definite amount of oxygen. These are the obligate bacteria. Thus an obligate aerobe will not grow unless there is a large amount of oxygen.

These facts contribute to our knowledge of controlling and inhibiting the growth of bacteria. As a result satisfactory antisepsics and disinfectants have been prepared. The former restrains the development of bacteria while the latter really kills them. These two methods of sterilization are more often of a chemical nature than a physical one. Heat is the most valuable destructive agent. Both dry and moist heat is used; the latter being the better of the two,
and very much better than hot air. Cold or freezing under pressure does not cause the desirable reactions. Drying or desiccation is effective in wiping out the influenza bacilli as well as those causing gonorrhea. Several methods, which result in the oxidation of the cells, cause the cells to literally burn up. These different methods of destruction in one way or another finally cause the coagulation of the protoplasm which ends in death. Spores contain so little water and such a hard outer covering that they are very hard to penetrate and bring about this coagulation. Thus they are resistant and extremely dangerous.

Virulence is the ability of an organism to cause disease, and often times denotes the severity of the disease. Toxicity, the amount and the kind of poison, and the invasive power of the bacteria determine the virulence. Some organisms such as tetanus do their destructive work by means of toxins, while anthrax bacilli possess invasion ability and multiply rapidly. It is not enough that an organism find a susceptible host but it must be able to live and multiply under the new environmental conditions, especially where there has been a change of temperature. Much consideration has to be given to the mode of entrance as well as the conditions found in the body. Ordinarily the skin is a good protective agent. This is true until some injury to the tissue or an open wound allows the entrance of bacteria. These open wounds may be no more than a pin prick but the fact that the skin has been broken causes the damage, often in the form of bacteremia where the organisms circulate through the blood.
system. Many bacteria injure the host if they are inhaled; while ingestion of the same would have caused no appreciable harm for the gastric juices and enzymes would have destroyed them before they had arrived at the site that would be most suitable for their propagation.
The Human Body and Disease in General

Saprophytes cannot be made to grow upon living tissue, but they can be pathogenic because of the toxins which they are capable of producing. There are a number of bacteria which are pure parasites and spread throughout the body. Half parasites produce disease if they become injected into the body, but they lack the power of invasion. Thus the mode of entrance is an important factor in the amount of damage that will be done.

Still more important is the condition of the host. The outcome of the battle between the individual and the organism depends largely upon the person's resistance to the organism or his immunity. This immunity is the power to overcome bacterial invasion. It is a characteristic of the individual as virulence is of the parasite. The organism and the patient fight for supremacy; the result will either be the recovery or the death of the latter.

Immunity is classified under two headings—natural and acquired. Races and individuals are born with certain physical peculiarities which give them a natural immunity to one or more diseases. Acquired immunity may be the result of recovery from the disease or may be artificially gained from vaccines. This artificial immunity may be active, in which case the individual, after stimulation, builds up his own anti-bodies, or passive when he has been inoculated with anti-bodies previously built up by
Another animal—usually the horse.

These anti-bodies are certain substances which possess the power to injure the disease-producing agent and counteract the effect of the poisons. They are found in the plasma and lymph, appearing very soon or not until the disease is well advanced. They are produced only as the result of the activity of the antigen and are antagonistic to the specific organism.

Antibodies, according to Todd and Sanford, are of three orders. One group seize the antigen, which is a toxin, while it is still in the blood and lymph rendering it harmless. Included in this group are the anti-toxins of diphtheria and tetanus. In the second order are the agglutinins, precipitins and opsonins. Here there is a combining element and also a ferment-like action which is extremely helpful in medicine. The Widal test is an example of the application of agglutination. The third order consists of antibodies with two combining affinities. One portion combines with the antigen; the other with the complement which is normally present in the blood. It is unable to react without the presence of the immune body. This type of antibodies is useful in the diagnosis of syphilis and gonorrhea. (1)

The phagocytes work along with the antibodies producing an action known as phagocytosis. Specialized leucocytes, or white blood corpuscles, collect at the point of invasion. They have the

(1) Todd and Sanford, Clinical Diagnosis pp. 523-4
power to surround and engulf the bacteria, after the antibodies have previously prepared them, and in this way destroy them.

In spite of this defensive mechanism, needless to say, countless numbers of bacteria gain an entrance to the body, find a suitable place in the appropriate tissue to develop and start the production of their poisons. The result of such action is a disease.

There are four large headings under which bacterial diseases are grouped. A disease is sporadic when there is only one isolated case of infection. Secondly a disease is said to be endemic when the organisms appear in the same area year after year. An epidemic is a sudden infection of a certain disease, which, working with rapid progress, affects an increasingly large number of people in a short time. Much the same as the latter but on a wider scale is the pandemic disease.

The damage which the pathogenic bacteria succeed in bringing about may take several forms in regard to the course of infection. One type, with common occurrence, is an acute infection. The course is short and severe in contrast to a chronic disease. A prolonged process, where the antibodies are not active enough to immediately combat the organism and the infection drags over a seemingly endless period of time, is characteristic of a chronic infection. Mixed infections are serious as the primary organisms prepare the way for the entrance of the secondary invader. This
condition can best be exemplified in a case where the aerobes provide suitable conditions for growth of the anaerobes.

Mere invasion does not constitute infection. Many bacteria are harbored in the tissues, on the surface of the skin, and on the membranes without doing any apparent injury to the host. It is only when they pass the normal barriers and enter the deeper tissues than an infection occurs. This illustrates the distinction between mere contamination and infection. However, the former may lead to infection and serious damage to the individual. Kolmer describes the course of the infection as follows:

The incubation period extends from the initial infection to the development of the general symptoms. The length of this period varies with each particular organism. The prodromal stage is when there is a wide spread but mild action upon the body. Next a high fever develops. This is when the disease is at its height, with its most severe attacks and special symptoms. The period of decline shows the individual overcoming the infection. This is followed by a variable length of time during which the patient remains somewhat weak, but is returning to health and is said to be convalescing. (1)

All parasitic diseases are infectious but they are not all contagious. The latter is one which is spread by direct contact and so becomes the most dangerous from a social point of view.

(1) Kolmer, Infection, Immunity, and Biologic Therapy pp. 58-62
It is the hardest type to control and wipe out. Several methods for holding these communicable diseases in check are proving themselves effective.

Bacteria will naturally attack the individual at a point of least resistance. With this in mind the first means of control begins with the individual's general health. Therefore at all times one's health should be kept at as high a level as possible. In this way organisms cannot easily find a channel through which they may enter. Good health can be the individual's natural resistance. The second preventive measure comes after the disease has gained an entrance to the community. All infected persons should be isolated to prevent direct contact and indirect carriage of the organism from the sick to well persons. Indirect conveyance usually occurs by contact with articles contaminated with blood, feces, discharges from the mucous membranes. Another control method consists of quarantining those persons who have been exposed to the disease. The length of time varies with the disease, and in this way the spreading of the organism is checked and early treatment can be administered if the exposed person should develop the symptoms. Along with the quarantine measure, one of the most valuable aids is preventive immunity. This may be either active or passive depending upon the available time for treatment. Active immunity is the most satisfactory when the disease breaks
out in the community, but passive immunity is the first thought when a member of the family has been taken ill. The most difficult measure is the tracing of the carriers. These are persons who seem to be normally healthy but who harbor the organisms in their system. Measures should be taken to kill these organisms which the individual's resistance is not strong enough to overcome, although he is able to prevent himself from contracting the disease. The last control measure is in the testing of food products and dairy outputs as well as the systematic checking of the bacterial count of the town's or city's water supply.
Specific Diseases and Their Causative Agents

Streptococci are round cells constantly associated in chains as the result of division in one plane. These chains may be long or short; the former have a tendency to be the more virulent. These cocci have no flagella and under ordinary conditions do not produce spores. There are two types of streptococci; those which show a green pigment and those which hemolyze the blood. In the former group are Streptococci buccalis and fecalis which are found in the mouth and throat and in the feces respectively. Most of the pathogenic strains belong to the latter group. The colonies which hemolyze the blood and lack the power to produce green pigment have the highest pathogenicity. Primary as well as secondary infections are caused by both strains of streptococci. They are the causes of erysipelas, scarlet fever, septic sore throat, and are accessory organisms in pneumonia, and meningitis. Suppurative and inflammatory conditions of the skin, joints and membranes are the result of streptococci as well as staphylococci. It is more apt to be the viridans strain however. There are seven strains of hemolytic streptococci; they have been grouped and labeled from A-G. The A group contains those strains which are pathogenic for man. Included in this group are scarlet fever, erysipelas, septic sore throat and pneumonia. The B and C groups contain strains pathogenic to animals other than man. D and E are
found in cheese and milk while F and G normally inhabit the
throat and respiratory tract. Strains which are normally har-
bored in the throat of one may be fatal to another whose resist-
ance has become lowered by previous disease.

Streptococcus scarlatinae is a strain of the hemolytic
streptococci which causes a toxic disease. This specific or-
genism is constantly present in cases of scarlet fever. The na-
ture of the disease is as follows: After a short incubation
period usually from two to five days after exposure, a sore throat
develops and this early symptom is constant throughout the course
of infection. There is a cutaneous eruption and the production
of toxin. The secretions from the respiratory tract and the dis-
charges from the middle ear contain the organisms. A large pro-
portion of people are immune as only one half of those that have
been exposed contract the disease. Children are the most suscep-
tible. There is racial immunity especially among the negroes. The
epidemics are the most frequent in the winter and early spring as
indoor association gives a wonderful opportunity for exposure and
direct contact.

The achievements in the control of typhoid, smallpox and
diphtheria are a credit to the medical profession, but the severity
of scarlet fever epidemics continues. When a disease breaks out,
immunization of the children in the affected schools should be car-
ried out. Susceptibility can be determined by the results compiled from the Dick test reactions. Private physicians and Health Department Clinics are equipped to carry out this immunization program. Quarantine in the case of scarlet fever is not as effective as previously thought. The principal reason being the fact that carriers are responsible for the spread of the disease, and many patients after the period of quarantine still harbor the hemolytic streptococci in their noses and throats. The period is long and there is a great loss economically. Besides these facts there are many cases which are not diagnosed correctly or go unreported; thus in spite of all the quarantine measures the disease spreads instead of being checked. Children under seven years of age are the most susceptible and the most exposed to the "germ". Therefore isolation of such children reduces the number of cases and the likelihood of the development of other children's diseases. Measles frequently is associated with scarlet fever. The future program should be with the view of using the available funds for immunization. It is safe and effective. A watch should be kept for carriers who so often spread the disease to non-immune persons. The isolation hospitals should be only used for persons whose home conditions are poor and who are so seriously ill as to require the treatment which an isolation hospital affords. Also persons who live in hotels and boarding houses should be cared for in a hospi-
tal as they are more dangerous to the community than the ordinary person. (1)

Septic sore throats are the result of the presence of hemolytic streptococci. The pharynx and nasal passages become ulcerated by the action of the bacteria and as a result cause secretions with traces of blood. Another strain of streptococci which has caused a large number of sore throats has been transmitted by milk which contained these hemolyzing organisms. This strain can be neutralized by antitoxins which have been prepared for scarlet fever but not by those of erysipelas. In this case the patient may have broken out in a rash, but one different from those common in the typical scarlet fever infection. There are only a relatively small number of these cases spread by contact. Recovery from this illness gives immunity when the patient is subjected to and checked by the Dick test. The best prophylactic measure is the pasteurization of milk from every source no matter how sanitary the dairy methods may seem.

The severe type of puerperal infection occurs as an epidemic due to the spread of a strain of Streptococcus hemolyticus. There are three ways in which the infection gains entrance to the body. One from the placental site directly to the blood stream, another from cervical laceration and the third from the endometrium of the uterus. Blood from an immune donor can be used in transfusion with good results and expectancy for a rapid recovery.

Erysipelas manifests itself as a skin inflammation. Hemolytic streptococci cause this eruption. It is a distinct strain as there are not usually any cases at the time of a scarlet fever epidemic. If the strain is the same, there would be some cases of scarlet fever and some of erysipelas. One streptococcal infection will increase the susceptibility to other strains. After the resistance has been broken down by anemia or malnutrition, the organisms enter through a wound which has been contaminated with nasal discharges from one already infected. It seems advisable to use polyvalent convalescent serum in severe instances.

Streptococcus cardioarthritis was first discovered by Dr. J. C. Small in 1927 when he isolated it from blood, throat and feces cultures of patients suffering with acute rheumatic fever, and chronic arthritis. The infectious origin of arthritis is supported by the clinical demonstration of the role of focal infections. Streptococcus cardioarthritis has been found in these foci and so streptococcal vaccines have been used in one form or another. Patients with arthritis are highly susceptible to streptococci. Treatment along lines of desensitization can be accomplished by administering subcutaneously an extract obtained from a suspension of Streptococcus cardioarthritis. These treatments if continued at intervals of four weeks over a period of one year should relieve the patient of all signs of arthritis. (1)

(1) Printed by the Wulford Biological Laboratories
From the above data we conclude that hemolytic streptococci are divided into distinct and specific strains each with its own symptoms and as a result a characteristic treatment.

Pneumonia is still one of the prevalent diseases of man. 10% of the deaths each year result from failure to combat the pneumococcus organism. These are lancet shaped organisms occurring in pairs and surrounded by a capsule. Chemically this capsule is of three types. The diplococci are often found in short chains.

It is an endemic disease with the majority of cases occurring during the winter, and in the city rather than the country areas. The city gives a greater opportunity for transmission especially where there is overcrowding. This makes easier the direct transfer from one person to another by coughing and sneezing. This moisture carries the infectious material for a considerable distance, spreading the organisms from the sick to the well persons.

There is a balance between the invading organism and the resistance of the individual. Recovery or death depends upon this balance which is controlled by the virulence of the organism and the natural immunity of the patient. Fatigue, hunger and the "common cold" aid in breaking down the natural resistance. Man is relatively immune; laboratory animals especially the mouse and rabbit are the most susceptible. This immunity is the result of
antibody action in the blood which is antagonistic to pneumococci. The actual death of the organism is not wholly due to these antibodies but also to the phagocytes which engulf the cocci. Some resistance is acquired by continued exposure to non-virulent strains, and in this way acquired immunity is built up.

Lobar and bronchial pneumonia are the two common types of the disease. The first is an inflammation of one or more lobes of the lung. This type causes 96% of the cases and one half the deaths. The other type finds the small air passages and there it sets up the inflammation. In lobar pneumonia the causative agent is the pneumococcus, while in the bronchial type the infection is the result of the combined action of streptococci, influenza bacilli and staphylococci.

There are many strains of the pneumococcus organism, and by agglutination tests they may be separated one from the other. Nineteen different strains have been tested, but 1, 2, 3, and 4 are the most common. Types 1 and 2 are rarely found in the upper respiratory tract of a healthy person but 3 is prevalent in the general population. Typing to aid in the diagnosis can be accomplished in a relatively short time by examination of the sputum. Specific anti-pneumonia serum has been perfected to combat types 1 and 2 and has proved very effective. Type 3 has shown no favorable result. The antibodies in the serum have been built up in the horse; this has proved more successful than those from the
blood of a convalescent.

Pneumonia is still a menace, because of the fact that all persons attacked by types 1, 2 and 3 cannot be treated with the serum. Persons with asthma, hay fever or previous treatment with horse serum will find the reaction to the pneumonia serum too violent to warrant its use. Furthermore all cases of pneumonia are not caused by a strain for which there has been prepared a serum. Unfortunately an attack by one strain does not give immunity to the other strains and so a person can be subjected several times.

Control measures consist of finding the carriers, isolating the diseased persons for the disease is highly contagious, and indirectly reducing the incidence by fewer occurrences of the other respiratory diseases. Early administration and adequate doses of the pneumococcus antibody serum produce the best results when checking pneumonia. We cannot expect immediate results for it took years of effort to control typhoid and diphtheria, but the work now being done shows great promise for the future. (1)

Gonorrhea is caused by a specific microorganism which Keisser found to be a bacterium and which he named gonococcus. Under the microscope it occurs in the form of a diplococcus arranged inside the pus cells. It resembles a coffee-bean with the flat sides apposed, and is very similar to the meningococcus organism. They lack flagella and do not produce spores. These facul-

(1) Lord and Heffron, Lobar Pneumonia and Serum Therapy, pp. 1-72
tative anaerobes attack the human urethra, but due to their low resistance they are readily destroyed by weak disinfectants. The period of infection is long; the organisms cause chronic urethritis, and when carried by the blood or lymph to other parts of the body they may cause endocarditis or ophthalmia. The gonococci may appear in secretions long after recovery has been pronounced.

Immunity from previous attacks is slight. Therapeutic serum is beneficial if the course of the disease has not reached the stage of septicemia. Three control methods would be effective if carried out. Insist upon infected persons reporting and receiving treatment as they would for any other contagious disease. Reduce the number of carriers, and lastly prevent exposure to the disease and in this way curtail infection. Two types of cases should be watched. The first is the patient who is thought to be cured and the second the case which is not easily recognized. Preventive measures must be directed towards the public; they should be made to realize the social seriousness of gonorrheal infection and the necessity for thorough treatment.

Sweden has a national law which controls venereal diseases. This act of the government lists syphilis, gonorrhea, and venereal ulcer as the infections which require submission to treatment and strict abidance to the directions of the physician. Free medical attention is granted in proportion to the yearly income of the infected person. Each physician is compelled to trace the infec-
fection to its source. Compulsory measures are taken against those unwilling to come for treatment and punishment is rigid for those who knowingly and through carelessness cause the further transmission of the organisms. Any person who obtains a marriage license is forced to show from reliable sources that he is free from the contagious stage of all of the above named infections. Although the law has been in operation only since 1919 a marked decrease in the occurrence of these diseases shows that the method of control is effective. The best results are shown in the cases of syphilis; this would lead to the necessity for better methods of treating the infectious stages of gonorrhea. (1)

If Scandinavia and Great Britain have been able to work out a suitable program for the elimination of the venereal diseases, why is not the United States able also?

Spinal or epidemic meningitis is caused most commonly by the meningococcus organisms. They are diplococci and occur in the pus cells. Another name and a well chosen one is Diplococcus intracellularis meningitidis. These organisms can be distinguished from the pneumococci for the former lack capsules, but the differentiation is not as readily made from the gonorrheal agents.

The organisms enter the body by the mucous membranes of the nose and attack the meninges of the brain. The spinal cord

(1) American Journal of Public Health April, 1936 pp. 357-63
is also attacked so that fluid, obtained by puncture of the spinal canal, contains the meningococci. The presence of these diplococci makes the diagnosis certain. If the diagnosis has been made soon enough after exposure, the organisms can be detected in the blood stream and the nasal secretions.

The disease is transmitted from man to man by nasal discharges and moisture from the mouth, as is the case with most infections of the respiratory tract. Carriers are a great menace and an important agent in the spread of this disease. They may be divided into groups according to the length of time that they harbor the organisms in the nasal passages. The permanent carrier is more dangerous than the temporary. But the chronic intermittent carrier very often transmits the strain that causes epidemics. Carrier eradication is the only means by which the prevalence of the disease can be diminished.

The therapeutic agent which in the past has proved effective, is the antimeningococcic serum which should be injected both intraspinally and intravenously. The earlier it is administered the better the results. More evidence in favor of the new meningococcal antitoxin should be accumulated before the standard treatment of the past is abandoned.

Such of our knowledge of this organism was obtained during the World War when the disease was so prevalent, especially
among the men in the training camps.

Suppuration or the formation of pus is caused by streptococci and staphylococci. The latter are groups of individual cells which occur in aggregations that resemble grapes. The production of pigment and the pathogenic power supply the basis for classification. The strain Staphylococcus epidermis albus lives on the surface of the skin and its pathogenicity is doubtful. The two most important organisms are Staphylococcus pyogenes albus and aureus; the former produces a white and the latter a yellow pigment. These are aerobic bacteria which do not have flagella or produce spores. Staphylococcus pyogenes albus is the common cause of pus generation. The aureus strain is widely distributed, occurring on the skin, in the mouth, nose, and eyes. The local infection appears in the form of abscesses and carbuncles. Having gained an entrance from a cut or scratch the bacteria may also circulate through the body. The hair follicles and sweat glands sometimes serve as portals of entry. The infection is more apt to spread to other parts of the body than from one person to another. Because of this the most efficient control and preventive measure lies in personal cleanliness and first aid treatments for such trivial things as cuts and minute scratches, as they may be the initial cause of more serious infections. Staphylococci also occur as secondary invaders in numerous mixed infections. These microorganisms are found in cases of osteomyelitis,
periostitis, and pneumonia. Stimulation of the phagocytes is the best method for preventing and curing infections from staphylococcus organisms. Autogenous vaccines increase the general resistance and stimulate the phagocytes to ingest the staphylococcus microorganisms. They are prepared from cultures of bacteria obtained from the patient himself, and they are more beneficial than the standard vaccines, in this case, because they neutralize the specific strain which is poisoning the system of the infected person. Both the albus and aureus varieties are found in the naso-pharynx region of healthy individuals. The consensus of opinion is that the "common cold" occurs when the resistance to these organisms has been lowered and the filterable viruses are allowed to enter the body. Some strains of staphylococci are members of the group of beneficial bacteria.

The second division of bacteria consists of the bacilli. They are rod-shaped organisms, often motile with a strong virulent capacity. Thus, many of this group are pathogenic and cause many serious diseases. The first discussion in this group will concern the diphtheria bacillus which has been so well controlled.

This microorganism is known as the Klebs-Loeffler bacillus; the name was given as a tribute to the men who prepared a special type of medium for the growth of this particular organism.
It is a straight rod about four microns in length and .5 microns broad with rounded ends. There are swellings about one pole giving a club-shaped appearance to the bacillus. The bacilli occur singly and are without flagella. Being aerobes they grow abundantly in the presence of an excess of oxygen and so very naturally when they lodge in the throat they find conditions ideal for reproduction.

The infection is in the form of a membrane that spreads over the surfaces of the tonsils, epiglottis, larynx and uvula. The result is an extremely sore throat. The inflammation is localized but because of the toxins produced the virulence of the organism is greatly increased. Diphtheria is a typical toxemia. There are two methods by which one may contract the disease. The first and most common is from contact with a sick person so that the organisms are transmitted directly from the nose and throat of the patient to the healthy individual. The portal of entry to the body is the mucous surfaces of the nose and pharynx. Articles soiled with discharges from the nasal area may serve indirectly as transmitters. The second method is by contact with healthy carriers who are harboring the organisms in their throat. Now and again epidemics are caused by milk which has become contaminated.

Persons who were exposed and were fortunate enough not
to contract the disease had a sufficient amount of antibodies in the blood to neutralize the pathogenic substances. The Schick test is a reliable method for testing the presence of these antibodies. A failure to react suggests that the natural immunity necessary to combat the disease and neutralize the poisons that the organisms will produce is present in the individual. A positive reaction is shown by a slight redness and indicates that it is advisable to start treatments which will result in immunity. This can be accomplished by injections of a small amount of toxin which will stimulate the antibodies, and at the same time enough antitoxin should be given so that the reaction of the individual will not be too severe. This is an active antigen which stimulates the production by one's own cells, and the resulting immunity will last longer than the passive type. This is only effective for a short period but is excellent to prevent contraction of the disease after exposure. Passive immunity can be obtained from inoculations of antitoxin which has been prepared after active stimulation of the horse. The antibodies are produced in the same manner as when human beings are injected with toxin-antitoxin. Blood with the antibodies is standardized and made suitable for human injections giving immediate but not lasting immunity. Intramuscular injections of antitoxin are the best because absorption is the most
Prevention takes the form of testing to discover the amount of natural immunity. Then toxin-antitoxin can be administered according to the findings. Children are given a milder preparation known as toxoid which will protect them until the period of natural immunity is reached. Children are the most susceptible so it appears that as we grow older we produce antibodies. Another prophylactic measure is the detection of diphtheria carriers. The persons who persistently harbor the organisms in their throat after recovery are called convalescent carriers. Those who have not contracted the disease but who have been exposed continually to the sick may become contact carriers. The danger lies in the fact that the organisms remain virulent for a long period of time and the carriers spread the disease unconsciously.

With such a well worked out program for prevention there is no excuse for persons having diphtheria. However, many parents fail to provide this safety for their children. As a result there are still deaths recorded from diphtheria. There are three causes for these deaths. The first type follows asphyxia when surgical treatment is not successful. Another cause of death is bronchial pneumonia which many times develops after the patient has been saved from asphyxia. The third group of fatali-
ties results from the development of myocarditis which is the termination of toxemia. Antitoxin alone will not save the patient if the membrane develops below or within the larynx, and tracheotomy is the final measure. (1)

*Bacillus anthracis* is a non-motile, aerobic rod-shaped organism. This specific microorganism is pathogenic and produces endospores. Anthrax infection occurs in several different ways. Inhalation will cause a pulmonary infection if the numbers inhaled are large and the resistance of the person low. The bacilli will localize in the lungs. If ingested the spores will reach the intestines and are passed out of the body without doing any harm. The most serious channel of entry is through the skin to the blood stream. Cuts and other cutaneous wounds afford the break in the skin. Persons occasionally die from infections received from using shaving brushes which are contaminated with anthrax spores.

Another disease of domestic animals which man is able to contract is glanders. The bacillus causes infection particularly in veterinarians and others who care for horses. The acute form is the most common, infecting the mucous membranes of the nose. These cases are practically all fatal. In the chronic type the patient is more apt to recover. There is no immunity to these non-motile, non-spore producing, small but

(1) *The American Journal of Medical Sciences* Volume 191, 1936 p. 276
straight rods.

The hemophilic bacteria constitute a group with characteristic pathogenic symptoms. The bacilli are small, their growth scanty, and as a natural result their study has been difficult. Hemophilus influenza, the Pfeiffer bacillus, is one of the smallest, being only 1.5 microns in length and .3 microns thick. This non-motile rod-shaped organism does not produce a capsule or spores. It occurs in the spinal fluid of a patient with meningitis, in cases of measles, whooping cough, and tuberculosis. This shows that the best environment for its growth is in the presence of other bacteria, as a member of a mixed infection. Besides conveyance on particles of dust, the best and most effective mode of transmission is by direct contact.

The organism which causes whooping cough is also a member of the hemophilus group. It is Bacillus pertussis; this short, oval and non-motile aerobe causes a highly contagious disease which is extremely prevalent among children. The causative agent is also known as the Bordet-Gengou bacillus, the name being derived from the men that prepared a special medium for its growth. The infection is characterized by recurrent attacks of spasmodic coughs and a decided increase in the number of leucocytes in the blood stream. The "germs" are found in large numbers lying in the pus cells of the sputum.
The spread of these organisms has not been checked as has that of many diseases. This can be seen from the yearly rise in the total cases. The vaccine, as in typhoid fever, is an immunizing but not a curative measure. However, a new preparation for the treatment of pertussis has been put on sale, but as yet has not received universal approval. The prophylactic vaccine takes several months to obtain the desired effects. Numerous deaths occur during the first two years of age; therefore, if this immunization is to be valuable it should be administered about the sixth month after birth. Failure to become immunized may be due to the lack of power in the body to build up antibodies after stimulation by the antigens, or the latter may not have been potent.

An experiment with 1,000 Cleveland children between the ages of six and fifteen months shows the following results. 482 infants were vaccinated against whooping cough. 496 of the same ages and as nearly alike with respect to home conditions and care as possible, were observed as the control group. 61 of those that had been inoculated were attacked; 71 in the control group also contracted whooping cough. There was one death in the latter group. Regardless of the fact that the investigation showed that those who were inoculated had a milder
form of the disease, the need for improved treatment is clear. (1) The organism must not have the opportunity to continue its harmful invasions. Isolation of the infected children in the neighborhood is one's only safeguard. Avoid the idea "that he will get it anyway, so let's get it over with"; for the older a person is the less severe the attack.

A large group of bacilli which are pathogenic includes the bacteria that cause typhoid fever and dysentery. These organisms are straight rods with rounded poles which frequently bear flagella. Spores have never been observed on cultures of these organisms grown in the laboratory. These motile bacilli of the colon-typhoid group can best be considered if subdivided into three classes. The first includes Bacillus coli which is widely distributed throughout water, soil, and the intestines of man from whence came its name. Typically these organisms possess flagella arranged at the poles. Nearly all healthy persons harbor these bacteria in the lower alimentary tract and as a result large numbers are found in the feces. Their occurrence in water is an indication of sewage contamination. They are not harmful in themselves but their presence gives suspicion, and rightly, that there are pathogenic strains in the water.

The second group contains the paratyphoid bacilli. The symptoms which they cause are similar to those of typhoid fever but on a milder scale. These disease-producing agents can be isolated from infected water, meats and milk which have caused food poisoning. The low mortality rates result in a lack of valuable information for few autopsies have been performed. The bacilli appear to be of two strains; type A and B, the latter is more widely distributed.

The most serious diseases are the true typhoid and dysentery epidemics. The typhoid bacillus is a short rod about two microns in length actively motile with characteristic peritrichal flagella. Infection is the result of ingestion of food which has been contaminated with these microorganisms discharged from human feces and urine. After ingestion the organisms, which are preferably parasitic, become lodged in the intestines and there they cause ulcerations in the wall which are known as Peyer's patches. Headache and lack of appetite is accompanied by diarrhea. The organisms are capable of invading the body by way of the lymph stream, and so the spleen becomes enlarged and contains a large number of bacilli. Many of the chronic carriers harbor the organisms in the gall bladder; and frequently the sputum can be used for detection.

In many towns the sewage disposal plant and the reser-
voir for drinking water have been built in the same locality. It is no wonder that the water becomes contaminated unless strict watch is maintained. Fresh pollution of water tends to cause serious infection but with the passing of time the infection will diminish, unless the contamination continues. Persistence in a given area would suggest that the surrounding soil had become saturated. Milk causes infection, when the milk bottles and other utensils are not properly washed and small amounts of contaminated water are left in the bottles. Flies are very frequent carriers of the disease, infecting otherwise harmless food.

Typhoid bacilli may also be carried by individuals. Organisms from the feces of one individual are carried by water or other means to the digestive tract of another person. The fact that the disease is spread by contact with carriers through the food which they have handled cannot be over-emphasized. These carriers may be dangerous for as long as six months after they have been considered cured. Because so many people become involved when carriers are engaged as foodhandlers, state laws have been enacted prohibiting carriers from working in public eating places.

An incident which occurred last summer will illustrate the seriousness of these carriers. A number of people
were the guests at an American Legion supper. Shortly after this supper typhoid fever broke out in the community with 86 persons ill from the disease. Immediate work was started to trace the source. Five days after the occurrence of the first case, the cause was discovered. All persons who had had anything to do with the preparation of the food were tested by the Widal test. The potato salad was found contaminated and the results of the laboratory tests showed two positive reactions; in this way the source of the infection was traced to the woman who had made the salad. Every person who had been at the supper had to be immunized and so 212 persons were affected by this one chronic carrier. (1) One cannot help recalling the well known story of "Typhoid Mary" when considering the carrier problem.

Immunity is to some extent acquired by recovery from attack. Increasing amounts of protective vaccine injected into the arm give satisfactory and successful results to persons expecting to visit districts where the infection exists. Relief workers are thus protected before going into flooded areas.

The chemists of the Eli Lilly Company claim that oral administration of dead typhoid bacilli as an immunizing agent is as good as the subcutaneous methods and decidedly

(1) American Journal of Public Health September, 1936 pp. 313-17
more desirable for the patient. The capsules contain ten trillion heat killed typhoid bacilli which have been ground with starch. Three capsules will immunize the individual who is likely to be exposed; the only reaction is a slight intestinal disturbance. Digestion of the bacilli results in the absorption of the typhoid antigens so as to stimulate antibody formation and increase the body resistance to the organisms.

Either the inoculation, which takes from four to six weeks to bring results, or the oral administration is only a supplementary precaution to be used in conjunction with strict sanitary measures. Prophylactic vaccine reduces the incidence of typhoid fever and gives immunity. In 1933, 450,000 men in 1,000 C.C.C. Camps were vaccinated against typhoid and according to Major Patterson, these men were sent to various parts of the country. In spite of the fact that many of these places were typhoid areas only 54 cases developed. Only four of these ended fatally. 22 of the cases and one of the deaths was attributed to the fact that one company drank water from a well which was very shallow and the surrounding conditions were unsanitary. (1) This proves that vaccination is in the majority of cases reliable, but there should be a careful check upon the sanitation regularly.

(1) American Journal of Public Health Volume 25 p. 262
A new development in the treatment of severe cases of typhoid fever is by blood transfusions. This is effective if the course of the disease has taken a toxemic form. To test this treatment 41 persons were placed in an experimental group and 34 persons in a control group. The first group was given the blood transfusions and only ten died; there were sixteen deaths in the latter group. Although this is only a preliminary report, and 41 persons is not sufficient to give definite conclusions, it is reasonable to think that blood containing a large proportion of poison could be replaced successfully by new blood. The donor must, however, have protective elements that will work against the infection. There seems to be sufficient value in this experiment for future work to be done along these lines. (1)

Dysentery is a clinical name given to certain pathogenic conditions of the alimentary canal. The symptoms are similar whether they are caused by amebae or by bacilli. The outbreak in Chicago in 1933 was caused by the former, a protozoan, Endameba histolytica. It is transmitted, without question, by water. The bacterial disease is caused by the non-motile Bacillus dysenteriae which is always in the stools of the infected persons. It is conveyed to other persons through polluted water or direct contact with human germ carriers. Un-

(1) American Journal of Medical Sciences Volume 191 pp. 850-2
til recently it was considered a tropical disease, but it has been introduced into the United States and large European cities.

There are antitoxins but attempts to prepare toxoids have not been successful. The safest measure of control is the enforcement of up-to-date plumbing with the installation of approved water supplies and drainage systems.

In 1897 Dr. Shiga prepared a vaccine from bacilli killed by heating, and when he administered it to himself the reaction was so severe that he would not give it to anyone else. A sero-vaccine is less severe and absorption is rapid, but individuals are also sensitive to this treatment. Oral vaccine is now being widely used. In 1889, the year that the dysentery bacillus was discovered, there were 90,000 cases in Japan. The number of cases has been greatly reduced due to the policies of prevention since the discovery. Carriers are as much of a problem as in the control of typhoid fever. These carriers, if the numbers become great enough, give rise to epidemics. 30% of those convalescing and 9% of those who are in contact with the patients are carriers; many remain infected for as long as eight months. Fortunately control methods are being perfected both in Europe and America. (1)

(1) New England Journal of Medicine December 24, 1936 pp. 1205-11
Melita Fever is caused by Brucella melitensis bacillus. It got its name from the fact that it was extremely prevalent on the island of Malta. It was also called undulant fever from the character of the course of infection, but now the popular term is Brucellosis. The specific microorganism is a coccus-like bacillus occurring singly or in pairs but never in chains. Bruce went to Malta to study the disease and he found that the organisms were transmitted to man from goats milk. The course of the disease is long whether the case is of an acute or chronic nature. There are arthritic pains, fever and chills which continue for as long as four months. The blood is the most common source for obtaining cultures but the feces and urine are also contaminated. The laboratory tests are useful only as adjuncts to the clinical picture.

In 1924 the disease was for the first time recognized in America. The cattle raising areas in the South and West were especially affected. The first case in Massachusetts occurred in 1930. Five years later the number of cases had increased to 42 and one death was recorded. This is a new organism which the state health officers and physicians will have to combat. Pasteurization will limit the source and treatment with Brucella vaccine is valuable. Fortunately 85%
of the population of this state are protected by compulsory pasturization laws. (1)

The organism Bacillus pestis causes a disease which in the 14th century was known as the Black Death. It received this name because of the subcutaneous hemorrhages which form dark spots just under the surface of the skin. The bacilli occur in non-motile pairs without spores. Large numbers of the organisms appear in inflamed and swollen glands. They gain entrance to the body by way of the skin; only a few cases have been known where the bacilli were swallowed and caused infection. The disease localizes in the tonsils and the respiratory tract. The toxins that are produced are not in as close an association with the cell as in cholera or typhoid, but they are diffused through the surrounding media as in tetanus and diphtheria. This highly infectious disease is closely associated with filth, and poverty so that crowded living conditions foster the rapid spread from sick to well persons. Thus there is difficulty combating the disease without extensive improvements which would raise the standard of living. At the time of an outbreak among human beings there is also a high mortality rate among rats. They suffer from the same strains that produce disease in man. In this way the disease can be carried from

one port to another in spite of the fact that all of the
seilors are healthy. Plagues are of two types. One the glan-
dular where the organisms get into the blood stream and the
other, a type of pneumonia which is often fatal. The first
variety of plague is more commonly known as the Bubonic
Plague because of the characteristic bubos that are formed.

One important group of bacteria is composed of
the spore-forming anaerobes. They are pathogenic rods somewhat larger than the majority, and they produce resistant
spores. The distinctive feature which sets then apart from
the other groups is the conditions under which they grow.
Anaerobes are only able to maintain their life processes in
an environment where there is a lack of oxygen. Because of
this tendency mixed infections are the ideal situations for
the development of the tetanus bacillus. Also botulism or
food poisoning comes from the development of spore-forming
anaerobes which have contaminated pork products especially sau-
sages. When these products are taken into the digestive tract
without having been properly cooked the individual becomes in-
fected.

Tetanus is the spasm of the voluntary muscles es-
pecially those of the neck and jaws. From this condition the
common term "lock-jaw" has been coined. The bacilli are elen-
der rods with rounded ends and flagella surround the cell. These rods often form short chains and they appear somewhat enlarged due to the presence of the spores. As it is an obligate anaerobe, a mixed infection supplies the most favorable growing conditions. These organisms along with various others gain entrance to the body when a subcutaneous but deep wound has been infected and the surface has then healed over. Statistics show that more than 70% of the cases of tetanus follow insignificant injuries. The organisms are not carried throughout the body, but the toxins that are produced are absorbed and cause the injury. These toxic substances attack the axis-cylinder of the peripheral nerves and continue to the central nervous system giving muscular contractions.

War wounds, fire cracker accidents, and nail punctures which have been contaminated by fertilized soil are the typical conditions which encourage the development of Clostridium tetani. The wounds should be disinfected and antitoxin should be administered immediately so that the poison will be neutralized as fast as it is formed and the nerves will be prevented from absorbing the toxin. There is also the necessity for active immunization especially among children and soldiers. The development of tetanus antitoxin in the blood is influenced by age, physical condition, and the type
of previous diseases. Immunity acquired by active methods is a long process but it is more reliable than the passive immunity, which has its limitations.

Clostridium botulinus appears as a large rod with from four to eight peritrichal flagella. Ordinarily the organisms occur singly but short chains sometimes result from the lack of complete fission. This organism like the tetanus bacilli is doubly dangerous as it grows under anaerobic conditions and produces spores. Each spore is situated at one pole of the bacillus. Food poisoning is caused by the toxic substances produced by the organisms. It is not neutralized by the gastric-intestinal juices and attacks the motor nerve centers causing muscular weakness. The poisons are powerful, and four times as much antitoxin is necessary to counteract their action. To be effective the antitoxin must be given before the toxin has circulated through the body. Prophylactic measures such as cattle inspection, canned food laws, and proper home cooking are the best safeguards against food poisoning.

Associated with the anaerobes is gaseous gangrene. The infections are not produced by one specific microbe but by several agents which are associated together. The commonest and most important of the group is Clostridium welchii, a non-
motile bacillus. Usually it occurs singly and spores are rare, but when they are present they are medial. Development progresses only in the absence of oxygen; thus Clostridium welchii is a strict anaerobe.

Another organism in gangrene, a condition where the muscle cells become filled with gas, is Cl. novyi which is much the same as Cl. welchii but the spores are subterminal. Bacillus histolyticus is a motile member of the group with as many as twenty flagella and spores. All of these organisms are present in mixed infections, especially war wounds, but they do not occur in pure cultures.

There are two new therapeutic treatments for the above infections. One consists of packing the wound with gauze saturated with antitoxin-gangrene serum. An opening in the center allows drainage. After five or six days the packing is removed and the surface has healed. The other recent development is the use of X-rays. The treatment should be begun as soon as the disease is suspected and continued twice a day for at least three days. This has brought about such improvement in the condition of the patients that it is no longer advisable or necessary to perform amputations. The new doctrine advocates the use of the X-ray in all cases, inoculations with anti-tetanus serum, anti-amputation measures, in
addition to the usual local surgery and antiseptics. (1)

In 1882 Robert Koch discovered a slender rod-shaped bacterium occurring singly. These bacteria when transplanted to another reproduced the same disease and the bacteria were identical with the original causative agents. The disease has been called tuberculosis from the presence of bacilli in typical tubercles. These bacteria are aerobic and non-motile; the human strains are capable of differentiation from the avian and bovine types. The organisms show great resistance to heat, drying, and disinfectants but direct sunlight rapidly kills them.

The organisms gain entrance to the body by inhalation of contaminated particles of dust as well as from drinking cups and infected foods especially butter and cheese made from contaminated milk. Many factors influence the development of the organisms after they have gained a portal of entry. The number, the virulence of the organism, and the resistance of the host to the invasion are important. If the number is small and the body immunity good, then there will be little damage done. On the other hand, favorable conditions for growth will result in the production of a serious infection. The most common site for localization is in the lungs, in spite of the fact that these acid-fast bacilli have the

(1) Journal of the American Medical Association 1935 pp. 1114-8
power to invade nearly every organ and tissue of the body.

The blood and lymph systems cause this wide distribution. Ford describes the production of the characteristic and visible tubercles. There is formed a hard mass of tissue about the size of a millet seed, in the center of which can be found a large cell containing a number of nuclei. Microscopic examinations show that the bacilli are in this giant cell. Surrounding it are mononucleated and lymphoid cells. The entire portion being enveloped in a network of fibrin.

Disintegration of the central portion results in a characteristic "cheesy" substance. It was because of this destructive process that the bacilli were named the tubercle bacilli.

The technician may suspect tubercular infection when no bacteria can be found in pus. (1)

Several factors such as crowded city conditions, poor food, alcoholism, and unhealthy living, result in lowered resistance and lead to the susceptibility of contraction.

There is no natural immunity to the infection, but there seems to be to the disease itself. Statistics show that the Irish and the Negroes are the most likely to develop the disease. The resistance of the race depends on the amount of immunity that the majority of its members have built up. If the race has just come in contact with the organisms its susceptibility

(1) Ford, Textbook of Bacteriology pp. 227-34
is great.

When considering hereditary transmission, it appears that the bacilli are not likely to be passed on to the newborn through the germ plasma, for the egg would not develop if it were infected. Placental infections occur but they are rare. The young may develop the disease if the mother is tubercular and the young suckled. Thus inherited tuberculosis seems to be nothing more than lack of the power to destroy the bacilli.

Acquired resistance to the organisms is set up by the first infection which produces immunizing bodies that are able to overcome the invasion by destroying the bacilli. A mild form of first infection also builds up the resistance to subsequent infections. The inherited power to destroy and this acquired resistance work together to give as complete immunity as possible; no one is totally unsusceptible. The goal since the bacillus was isolated has been to find a specific cure. In spite of the fact that the goal is still in the distance, knowledge of the resistance of man is going to be a step in that direction.

The decrease in the number of deaths due to infection with tubercule bacilli is not the result of one specific cure, but the combined effort of the sciences. In view
of the fact that no one treatment can be used in preventing or curing the disease, the most effective control lies in the work of the clinics. They care for those exposed and follow up and give after treatments to those patients whose case has been termed arrested rather than definitely cured. The future program lies in keeping up the standard of living, wider knowledge of sanitary conditions and the reduction of the number of carriers, who are a real menace. With the cooperation of every patient and each member of the community, tuberculosis could be greatly reduced if not exterminated. A large percentage of the difficulty lies in the fact that the infected person does not realize the seriousness of the infection.

The prevention program requires adequate food, sleep, fresh air and exercise. The years from fifteen to forty-four are the period when the population is the most susceptible, especially the latter years of adolescence and early maturity. As this group takes in the large number of youths in college and because the students' living habits are not well controlled with respect to their health, campaign measures for the reduction of tuberculosis are being started in colleges. The American Student Health Association has worked out a program of case finding which includes reports
of past histories, physical examinations, tuberculin tests and X-rays. Ten times more cases have been reported where the college or university has taken up this program than from the campus without the supervision. However there is no comparable data to indicate whether or not tuberculosis is more prevalent among college students than among other groups of young people. Infection is more common among men, but the incidence of disease is higher in women. (1)

Science is still striving to successfully combat this organism which lodges itself in the parenchyma tissue of the subpleural layers of the lungs and from there works to other parts of the body.

Bacillus leprae causes an infectious disease commonest in tropical countries but by no means rare in Europe and Iceland. The organisms closely resemble the tubercule bacillus appearing as a slender rod without the ability to produce spores or capsules or any means of locomotion. However they are more readily stained and more easily decolorized. The disease runs a slow chronic course with infection likely to appear in any part of the body. After an incubation period which may last several months the disease will develop into either tubercular or nervous leprosy. The former may be described by three distinct stages. The macular, with the first

(1) American Journal of Public Health Volume 25 pp. 1118-21
eruption, the nodular stage with the formation of tubercles, and the ulcerative, when the tubercles suppurate,--these stages terminate in death. Nervous leprosy is similar but the infection is localized in the nervous tissue rather than on the skin. The disease is not prevalent because the tendency to hide the knowledge of infection is less. The likelihood of spreading the disease is reduced proportionally with the treatment given. Absolute sequestration as practiced in the past is inhuman.

The present attitude should be the same as for tuberculosis, where the patients are allowed to travel to sanatoriums where the sunshine and pure air will aid their recovery. Unfortunately leper clinics are only found in leper areas. China is the most heavily infected of the leper countries. Here more than a hundred persons are consulted and treated each week at the large clinics which are equipped with the latest appliances. The patients are not cured, but the cases are recorded as arrested. In many instances the organisms have caused the recurrence of the disease.

The most important pathogenic spirillum is the causative agent of Asiatic Cholera. The specific bacterium is Spirillum cholerae or Vibrio cholerae. This strictly aerobic organism appears as a slightly twisted or curved mi-
crobe which does not produce spores. For this reason its resistance to physical and chemical agents is not great.
The cell reproduction of these active organisms is by transverse fission. When a European physician was pipetting a broth culture containing the organisms, he accidentally drew some into his mouth. As a result he contracted a disease known as Asiatic Cholera. This incident established the relationship between the spirilla and the disease. Carriers are the most abundant where the disease is prevalent, and a large number of healthy persons harbor the microorganisms in their intestines. Also, convalescents show the germs in the feces but rarely in the urine, as the infection becomes localized in the intestinal walls rather than other organs of the body or the blood stream. As in typhoid fever the mode of transmission is from infected drinking water, and occasionally members of the same household as the patient contract the disease. The organisms must be swallowed to cause sickness. Passive immunity is not in general use, but the active stimulation of the antibodies is widely advocated, and this prophylactic measure has been a success.
DIGEST

Pathogenic diseases can be classified as controllable and uncontrollable. The former are those diseases, the cause, the prevention, and treatment of which are known. This knowledge would wipe out these menaces if it was only put into practice. The latter group contains those organisms about which there is still not enough known or material compiled to term them conquered. In both groups the causative agents are in many cases bacteria. In other cases the invaders have not been isolated, and at present they are referred to as filterable viruses. However, the organisms in the filterable virus group may at some future time be found to be bacteria.

Controllable

\[
\begin{align*}
\text{Diphtheria} \\
\text{Tetanus & serum useful before the symptoms develop} \\
\text{Typhoid Fever} \\
\text{Smallpox & prevention but not specific cure} \\
\text{Reabies & serum useful before the symptoms develop} \\
\text{Yellow Fever} \\
\text{Malaria} \\
\text{Scurvy, Beri-beri, Bellogra, Rickets & lack of vitamins} \\
\text{Hookworm disease} \\
\text{Tularemia} \\
\text{Syphilis}
\end{align*}
\]
Uncontrollable

Pneumonia
Leprosy
Meningitis
Gonorrhea

Bacteria
Tuberculosis
Arthritis
Scarlet Fever
Bubonic Plague
Cholera
Undulant Fever

Measles

Filterable Viruses
Encephalitis
Poliomyelitis
Influenza
Psittacosis
Typus Fever
Rocky Mountain Fever
Cancer (l)

Fourteen out of the thirty-two of these major diseases have been checked. One prick and one dose of toxoid will protect a child from diphtheria; several scratches likewise will be insurance against smallpox. The vaccines protect society from invasions of tetanus,

(1) Davis, The Advance of Science, p. 242
yellow fever, and typhoid. Sanitation keeps the water supplies and food products from becoming contaminated. The body puts up a good fight even without the aid of medicines and professional care and treatment. This resistance is scientifically called immunity. In the future, the other eighteen diseases will be wiped out when the degree of immunity of each tissue is discovered. Two examples, staphylococcus and pneumococcus, will show the types of body resistance. The introduction of staphylococcus will cause a boil, and the inflammation around the invaders sets up a carrier so that the infection is localized immediately. In the case of pneumococcus, the obstruction is not set up for several days thus giving the organism a better chance to continue the invasion.

Diphtheria is a rare example of a disease for which there is both a therapeutic and a prophylactic treatment. The work which has been done on this organism has brought worthwhile results. Smallpox is one of the oldest known diseases and vaccines, specific antigens prepared in such a way that the resulting product is safe for injection, have proven successful in the prevention of its occurrence. On the other hand, many organisms still keep the medical profession in the dark. There are many functions of streptococci which are still undetermined, as the same strain may manifest itself differently in the varying types of persons. The newest treatment for hemolytic streptococcus causing blood poisoning is injections of a red dye, prontosil. It prevents the reproduction of the organisms and thus the body is able to overcome the invasion. The Brucella organisms which are causing an increasing number of cases of Brucellosis is a new introduction to the
United States. Numerous experiments have yet to be tried before whooping
cough and poliomyelitis treatments can definitely be assured.

The communicable diseases are harnessed by quarantine and the
work of the public health officers in conjunction with the private
physician and the public clinics. The graph (fig. 1) shows the result
of research on several of the major diseases. Funds spent for research
are excellent investments with future generations as well as the pre-
sent population deriving the benefits. Economy along these lines will
be foolhardy and dangerous. The maintenance of health is worth all
expenditures placed for continuance. Besides this, knowledge should be
made accessible to all and should be in such form as to be intelligently
understood and carried out.

Work continues in various directions each center following
its lead, but in the end each will cooperate with the other to test the
worth of a new vaccine, sprays for the nose in the case of poliomyelitis,
or blood transfusions for the treatment of severe cases of typhoid
fever. For it is agreed that the health of each individual is an im-
portant feature of a happy life and it should be a community as well as
an individual concern.
DEATH RATES PER 100,000 IN MASSACHUSETTS FOR EACH CONQUERANIAL PERIOD ENDING IN YEAR DESIGNATED

APPENDIX

A virus is a poison. Many diseases are known to be, others suspected of being caused by these viruses. They are measles, smallpox, rabies, poliomyelitis, and yellow fever. These infectious maladies arise through the action of these agents and their toxins. The group contains some members that are extremely contagious, for example, smallpox; and others that are inoculative but not spread by direct contact. Rabies exemplifies the latter type. Other filterable viruses are born by insects as in the case of dengue fever. Porcelain or diatomaceous earth filters are used in separating the viruses from the bacteria, but do not give any definite knowledge of their size.

There is still no unanimity of opinion existing with regard to the exact nature of the viruses. Fortunately this exact knowledge is not essential in order to control their spread. If the definite nature had to be learned in order to accomplish any results there would be no vaccines for smallpox and rabies. No virus has yet been cultivated on ordinary media, but many of them have been grown in the presence of living cells. That is, in tissue which has been modified to suit the occasion. Growth of this type has
yielded valuable information and the products produced are suitable for prophylaxis. It can be demonstrated that after a virus has entered a cell no amount of anti-serum will injure it or disturb its activities. This proves that administration of convalescent or immune serum to an individual, after the symptoms of a virus disease have appeared, is without value.

Recovery in most cases gives lasting immunity. Many build up an immunity from repeated exposures to mild cases, so mild as not to have attracted attention. This, of course, is only true of those diseases which are prevalent; thus one does not acquire immunity to smallpox in this way. The immunity to influenza and the "common cold" is short and therefore reinfection is frequent.

Preventive measures depend on immunization and avoidance of exposure. The eradication of the breeding places of insects prevents the spread of the viruses which are dependent on this method of carriage from one individual to another.

Poliomyelitis is another and more technical name for infantile paralysis. The cause of this infection is not known, but a filterable virus is the suspected cause. It enters the body by way of the nasal passages and if the
antibodies in the nasal secretions are not sufficient to combat the invasion of the virus and neutralize it, it will pass to the central nervous system and multiply there. Here again the damage done will depend upon the resistance of the cerebrospinal axis. Children below the age of ten are more likely to contract the disease; those from the years one to five are the most susceptible. The probable organism remains in such close connection with the olfactory nerves and the central nervous system that protection and curative measures cannot reach the virus, thus, it goes on with its destructive work. Only man and monkeys are susceptible to the disease and fortunately there have been no instances of a second attack, so that recovery gives lasting immunity. The seasonal appearance which is in the summer and early fall suggested that the insects were the transmitters of this disease, but all evidence along this line has been discredited and man is the only means of spreading the infection from one to another. Quarantine measures are effective but the use of antiseptics in the nose and throat are more likely to increase the infection rather than prevent it. Immunity artificially acquired has not proved very effective in man. Positive evaluations of antitoxins can-
not be given as yet, except for the mental ease they produce by giving parents assurance that their children will not be attacked. The best measure is to avoid contacts which would be likely to end in infection. After the attack has been made, the best method for prevention of permanent paralysis due to weakening of muscles from the destruction of the nerve cells, is an early diagnosis, specialized care and exercise of the extremities, along with nourishment given from a prescribed diet.

Mumps, chicken pox, German measles and measles are several of the commoner and with the exception of the latter not too serious diseases which are in the virus group. In other words, the cause is not known and there is no method of immunization. Measles, however, is serious because of the condition of the body on recovery. Direct transmission of secretions from the mouth and nasal passages of one already infected to another is the method by which the disease is spread. Articles which are soiled by the same means can indirectly be of importance. The incubation period averages ten days. Then a fever with skin eruptions constitute the specific symptoms. The epidemic cycle is such that the winter and early spring months record the largest number of cases of the year. Quarantine periods ex-
ist for fourteen days after the last exposure. This is to prevent the spreading of the disease during the incubation period if the exposed person is going to contract the disease.

Smallpox is an acute and highly infectious disease. Characterized by a fever which lasts for three days, eruptions of the skin which form scabs and on healing leave typical scars, this disease is one of the most dreaded. The lesions may appear on every part of the body with the possibility of there being as many as 40,000 pustules. After the fluid and pus-like contents dry, scabs form. It is at the convalescent stage when the physician can determine whether or not the patient is going to be pock-marked and disfigured. Smallpox is one of the oldest known diseases and fortunately today it is almost entirely eliminated. The causative agent is not definitely known, but many times examination of the pustule contents show staphylococcus both of the albus and aureus strains as well as streptococcus pyogenes. In the majority of cases the disease is contracted from contact with another infected person and so the patients should be kept in a special hospital or if necessary for them to remain at home, strict quarantine should be observed. Flies and insects frequently carry the germs. The virus is believed to
enter the system through the nose and mouth. Fortunately one attack gives a lasting immunity. Vaccines are the best prophylactic measure and should be administered in infancy, again when the child starts to school, and all adults should be certain of protection by revaccination if an outbreak occurs anywhere in the vicinity.

Wolves, dogs, and cats are susceptible to an acute infection known as rabies. The poisons are transmitted to man from the salivary glands as the result of a bite. Wounds near the head cause paralysis of the muscles more rapidly than bites on the limbs. Hydrophobia is the usual term for the disease in man; the symptoms begin with inability to swallow. Convulsions which interfere with respiration and cause death may occur. If treatment is delayed more than fourteen days paralysis is very certain to set in. Treatments with vaccines prepared from heated viruses are the most effective. There has been a decrease in mortality because of the improved methods of treatment but further improvement depends upon the general public, especially dog owners. Muzzling brings difficulties, and so leashing has been substituted as a preventive measure. All stray and unlicensed dogs should be taken care of by the local Animal Rescue League. If owners of biting dogs are sufficiently penalized
the number of occurrences would certainly be reduced.

Viruses are obligate parasites which require an association with susceptible cells for multiplication. Acquired immunity to virus infection results from an active although an unrecognized infection. This mild infection is the consequence of the administration of virus vaccines. Infectious diseases are now divided into groups according to the causative agents. These are bacteria, spirochetes, fungi, protozoa, and viruses.
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